UTILIZATION OF WASTE

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USE OF GABBRO IN PRODUCTION OF FACING CERAMIC TILES

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The advantages of using gabbro rock, which is rich in calcium and magnesium oxides, in the production of ceramic facing tiles, instead of raw materials containing calcium and magnesium carbonates are discussed. It is shown that by adding ceramic tile scrap and increasing the slip viscosity, it is possible to improve the product quality and change over to one-stage firing of glazed tiles.

The traditional European technology for production of facing tiles is based on the sintering process determined by the reaction of calcium or magnesium carbonates with quartz sand. In the 1950s, carbonates were introduced via carbonate-bearing clay. Large carbonate inclusions in clay were hard to crush in milling and, consequently, by retarding the decomposition processes in firing, they caused the appearance of pinholes in the glaze coating, up to the formation of leached holes. Later, to accelerate the decomposition of carbonates, they were usually introduced via chalk or dolomite with a smaller particle size.

The transition from double to single-stage firing decreases the production cost. Single-stage firing imposes stricter requirements on controlling the process of carbonate decomposition in firing. It is necessary that all decomposition processes in heating should occur first, and afterwards the fusion and spreading of the glaze should take place, i.e., the time of gas emission from the ceramic substrate should not coincide with the time of fusion of the glaze coating. In this case, the released gases will not accumulate in the glaze melt, and the glaze coating will be free of pinholes.

The development of fast firing and especially single-stage firing has modified the requirements imposed on glazes. The new glaze compositions are called eutectic, as they have a very “short” viscosity characteristic: they fuse and spread in the last moment of tile firing (approximately 3 – 5 min before the start of fast chilling in the furnace).

To improve the quality of glazed tiles, eliminate the process of decomposition of calcium and magnesium carbonates in firing, and reduce the number and size of pinholes in glaze coatings, calcium and magnesium carbonates should be replaced by calcium and magnesium oxides. This will make it possible to reduce the duration of tile firing, i.e., to increase the production-line efficiency.

The Ural region has substantial deposits of gabbro (basalt) rock rich in calcium and magnesium oxides, which does not contain components decomposing with gas emission when heated (Table 1). This rock is mined in the Sverdlovsk Region: in Pervouralsk, Nizhnyaya Tura, and Kahckanar. There are abundant dumps with a virtually constant composition of fairly fine screenings.

In 1991, the Ceramic Works in Ekaterinburg replaced the facing-tile mixture, which contained marble crumbs, nepheline-sienite, quartz sand, Nizhneuvelskoe clay, Nev’yanskoe

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TABLE 1

Raw material	Content in ceramic mixture, %	Mass content in components, %								
		SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	free quartz	calcination loss
Nizhneuvelskoe clay	52.0	29.7	12.8	1.8	0.3	0.4	0.3	0.1	14.0	4.4
Hornblendite	25.0	8.3	4.0	4.8	3.2	3.8	0.1	0.4	–	–
Uvelskoe sand	15.0	15.3	0.5	–	–	–	–	0.1	15.0	–
Chamotte	8.0	4.6	1.5	0.6	0.3	0.4	–	–	–	–

kaolin, and broken facing tiles (chamotte) with another mixture not containing carbonates (%): 51 Nizhneuvelskoe clay, 16 quartz sand, and 33 hornblendite (gabbro screenings from Pervouralsk).

The elimination of carbonates from the mixture made it possible to improve the external appearance of the glaze tile surface and reduce pinholes. The oblique angles in the tile disappeared at the same time.

However, this mixture has several shortcomings. Even a small disturbance in the temperature difference between the top and the bottom part of firing furnace leads to tile deformation. Hornblendite in an amount of 33% leads to excessive sinterability (after 17 min of the first firing with a maximum temperature of 1030 – 1050°C, the water absorption of the tile is 13 – 14%) and increased plasticity of the mixture at high temperatures. A decrease in the hornblendite content at the expense of raising the free quartz content (over 30%) results in ceramic tiles cracking in the cold state. A decrease in the hornblendite content at the expense of increasing the amount of clay enhances shrinkage, which is high as it is (1.6%) and, consequently, enhances deformation.

The transition to using this mixture made it possible to lower the firing temperature to 1030 – 1050°C, at the same time decreasing the TCLE of ceramics, which caused some problems in selecting a heat-resistant glaze coating. Furthermore, the high content of ferric oxide in hornblendite (19%) determines its high density and leads to sedimentation of slip in the mixing tanks with density 1.53 – 1.54 g/cm^3.

To avoid deformation and high shrinkage, specialists from the Cierma Company (Italy) insisted on introducing 6% chalk at the expense of hornblendite. However, full-scale industrial tests showed no change in the levels of shrinkage and deformation. At the same time, the quality of the glaze coating deteriorated, as the number of pinholes increased as a result of decomposition of the carbonates.

The manufacturers at the Velor Italian firm (Orel, Russia) introduce 13 – 16% chamotte into facing tile mixture to eliminate deformation and improve the stability of properties and the quality of ceramics. The quantity of chamotte in the mixture used at one of the factories in Stary Oskol varies from 7 to 9%.

It appears expedient to introduce chamotte (about 8%) into the mixture based on hornblendite, thus decreasing the hornblendite content. Table 1 contains the estimated chemical composition for such a mixture.

The additional introduction of chamotte in the mixture will help to solve several problems: first, to decrease the deformation of tiles; second, to raise the firing temperature to 1070 – 1080°C, which will ensure the heat resistance of the glaze; third, the decreased quantity of hornblendite made up of chamotte will diminish the sedimentation of slip, although will not totally prevent it. It is possible to eliminate sedimentation of slip by increasing the slip density from 1.53 to 1.65 g/cm^3 and thorough sifting of the slip through a sieve with a cell size of not more than 200 μm.

Thus, the use of gabbro rock instead of chalk or dolomite in a ceramic mixture for facing tiles has improved the quality of glaze coatings by eliminating gas emission caused by decomposition of carbonates and shortening the duration of tile sintering. This result is especially important in single firing. By using a mixture with hornblendite, it is possible to obtain high-quality ceramic tiles in single firing, which is equivalent to saving around 200,000 US dollars per year on a production line with an annual capacity 1 mln m^2 of tile, and to significantly lower the production cost.